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B.8 – AIR QUALITY

B.8.1 INTRODUCTION

Section 8 of the Proposal evaluated the potential effects of the Project on air quality. Air quality is defined in the Proposal for the Casino Project (the Project) as the composition of outdoor air. Air quality was selected by Casino Mining Corporation (CMC) as a Valued Component (VC) because mining activities such as fuel consumption, vehicle movement, and material transfer generate air emissions that could cause deterioration of ambient air quality. As well, clean air in the Yukon is valued unto itself, but additionally fugitive dust and particulate matter may affect receptors such as rare vegetation, wildlife, surface water quality, and soil. Major air pollutants that were assessed include sulphur dioxide, nitrogen dioxide, carbon monoxide and particulate matter, as well as Greenhouse Gases (GHG).

On January 27, 2015, the Executive Committee requested that CMC provide supplementary information to the Casino Project (YESAB Project No. 2014-0002) to enable the Executive Committee to commence Screening. The Executive Committee considered comments from various First Nations, Decision Bodies and regulators on the adequacy of the Project Proposal in the preparation of the Adequacy Review Report (ARR). CMC provided a Supplementary Information Report (SIR-A) on March 16, 2015. Subsequently, the Executive Committee issued a second Adequacy Review Report (ARR No.2) on May 15, 2015 following a second round of review. CMC is providing this Supplementary Information Report (SIR-B) to comply with the Executive Committee's Adequacy Review Report ARR No.2; CMC anticipates that the information in the two SIRs and in the Proposal, when considered together, is adequate to commence Screening.

The Executive Committee has six requests related to information presented in Section 8 Air Quality of the Proposal submitted on January 3, 2014 and in Section 8.A of the SIR-A as well as supporting appendices. These requests, and the sections of the SIR-B where the responses can be found, are outlined in Table B.8.1-1 and the responses are provided below.

The effects assessment presented in the Project Proposal concluded that the Casino Project is not likely to have significant adverse effects on air quality after the implementation of mitigation measures. The air quality predictions from the model are the "best estimate" available to inform YESAB's decision making with respect to air quality effects from the Project. The responses provided herein do not change the conclusions stated in the Proposal.

Table B.8.1-1 ARR No.2 Requests for Supplementary Information Related to Air Quality

Request #	Request for Supplementary Information	Response
R2-123	The data inputs, as requested by ARCADIS and noted above, for the air quality model.	Section B.8.2.1.1
R2-124	Mitigations to reduce or eliminate the frequency and extent of air quality exceedances modeled including evidence for each mitigation's effectiveness.	Section B.8.2.2.1
R2-125	Unclassed air quality model outputs in a standard GIS format.	Section B.8.2.2.2
R2-126	Predicted change in dust composition during construction and operations.	Section B.8.3.1.1
R2-127	Discussion on additional dust sources such as project induced wind-based erosion, blasting, and traffic in relation to dust quantity, including details on the inclusion of these sources in air quality modeling.	Section B.8.3.1.2

Request #	Request for Supplementary Information	Response
R2-128	Water requirements for dust management and dust prevention strategies and details on any water additives.	Section B.8.3.1.3

B.8.2 AIR QUALITY MODELLING

B.8.2.1 Model Inputs

B.8.2.1.1 R2-123

R2-123. The data inputs, as requested by ARCADIS and noted above, for the air quality model.

As stated in the response to R262, CMC provided supporting data for the CALPUFF and CALMET models in the form of a detailed emissions inventory, including the data inputs for the construction and operation phase Project activities with potential emissions sources in Appendix A.8A Emissions Inventory for Construction and Operations. As detailed in the Draft Proponent's Guide: Model Documentation (YESAB, 2015), required model documentation should include the information listed in the left-hand column of Table B.8.2-1. According to YESAB, "the draft guide is intended for proponents planning projects that use modeling to predict project effects and describes the general information YESAB will require in the project proposal" (YESAB, 2015). CMC did not submit a standalone air quality model report, as the Draft Proponent's Guide: Model Documentation (YESAB, 2015) was not available at the time of Proposal submission. In the absence of Yukon specific air quality modelling guidelines, best available practices from other jurisdictions were adopted for the Casino Proposal, including the *Guidelines for Air Quality Dispersion Modelling in British Columbia* (BC MOE, 2008).

CMC believes that information provided in the Proposal and SIR A meets these information requirements, as listed in the right-hand column of Table B.8.2-1. Furthermore, CMC believes that replicating the air quality model is not warranted and will not further assist the Executive Committee to determine the appropriateness of the model and its predictions. The model input files have not been provided; however, further details on wind data, as requested, are provided below.

Table B.8.2-1 Model Documentation Provided for the Air Quality Model

Model Document Report Requirement*	Location of Documentation Provided
Description of the objective and scope of the model.	Section 8: Air Quality
Discussion of model selection, its applicability, limitations, and key assumptions.	Section 8.4: Project Specific Effects
Description of model conceptualization and modeling approach.	Section 8.4: Project Specific Effects
Summary of input data (e.g. baseline data) including derivation, uncertainty, documentation and source.	Section 8.3: Baseline Conditions Section 8.4: Project Specific Effects Appendix A.8A: Emissions Inventory for Construction and Operations
Summary of model parameters (e.g. dispersion rates of particulate in an air quality model) including derivation,	Section 8.4: Project Specific Effects Appendix A.8A: Emissions Inventory for Construction

Model Document Report Requirement*	Location of Documentation Provided
uncertainty, documentation, and source.	and Operations
Description of model validation and calibration including (if applicable) history matching, ground truthing, sensitivity analyses, comparison between synthetic and measured values etc	Section 8.4: Project Specific Effects
Presentation and discussion of model outputs including (if applicable) confidence, alternative scenarios, etc.	Section 8.4: Project Specific Effects

*From YESAB, 2015

As described in the Baseline Climate Report (Appendix 8A), wind speed and direction are measured on-site at the Casino climate station and data were provided from November 2008 through September 2012. A regional analysis to account for long-term variability in wind conditions was not deemed necessary as the measured site data are considered to be reasonably representative of expected long-term conditions.

The Project site wind speed data are presented in Table B.8.2-2. The mean annual wind speed is 2.3 m/s (8.3 km/hr). The mean monthly wind speeds are higher in the spring, summer and autumn and lower in the winter, with values ranging from 1.7 m/s in November to 2.7 m/s in May. The maximum hourly wind speed recorded between 2008 and 2012 was 14.9 m/s (53.6 km/hr). The predominant wind direction was northerly, followed by south-westerly (see Table B.8.2-3, Figure B.8.2-1 and Figure B.8.2-2)

Table B.8.2-2 Monthly Wind Speed at the Project Site Climate Station 2008-2012

Year	Wind Speed (m/s)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2008	-	-	-	-	-	-	-	-	-	-	1.8	1.5
2009	2.0	2.0	2.9	2.2	2.5	2.7	2.5	2.4	2.2	2.3	1.6	1.5
2010	1.7	1.8	3.0	2.8	2.6	2.5	2.4	2.2	2.4	2.4	1.7	2.1
2011	-	-	2.0	2.7	2.9	2.4	2.2	2.3	2.5	1.9	1.7	2.2
2012	1.8	2.3	2.2	2.4	2.9	2.4	2.4	2.4	3.0	-	-	-
Average	**1.8**	**2.0**	**2.5**	**2.5**	**2.7**	**2.5**	**2.4**	**2.3**	**2.5**	**2.2**	**1.7**	**1.8**

Table B.8.2-3 Directional Wind Speed at the Project Site Climate Station 2008-2012

Direction	% of All Directions	Wind Speed (m/s)			
		<1	1-5	5-10	10-15
North	27%	18%	72%	10%	0.1%
North-East	8%	31%	65%	4%	0.0%
East	3%	32%	65%	4%	0.0%

Direction	% of All Directions	Wind Speed (m/s)			
		<1	1-5	5-10	10-15
South-East	9%	21%	69%	10%	0.3%
South	16%	20%	75%	5%	0.1%
South-West	21%	24%	75%	1%	0.0%
West	6%	39%	60%	1%	0.0%
North-West	10%	22%	70%	9%	0.2%
% of Total Wind Speeds		**23%**	**71%**	**6%**	**0.1%**

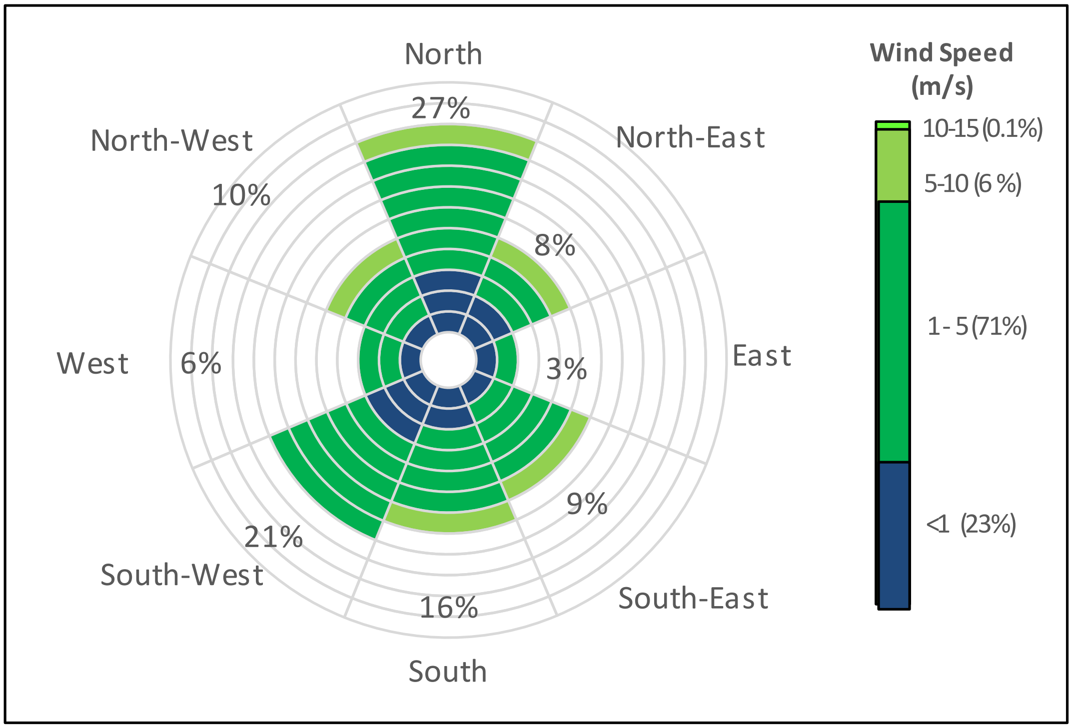

Figure B.8.2-1 Wind Rose for Project Wind Data 2008-2012

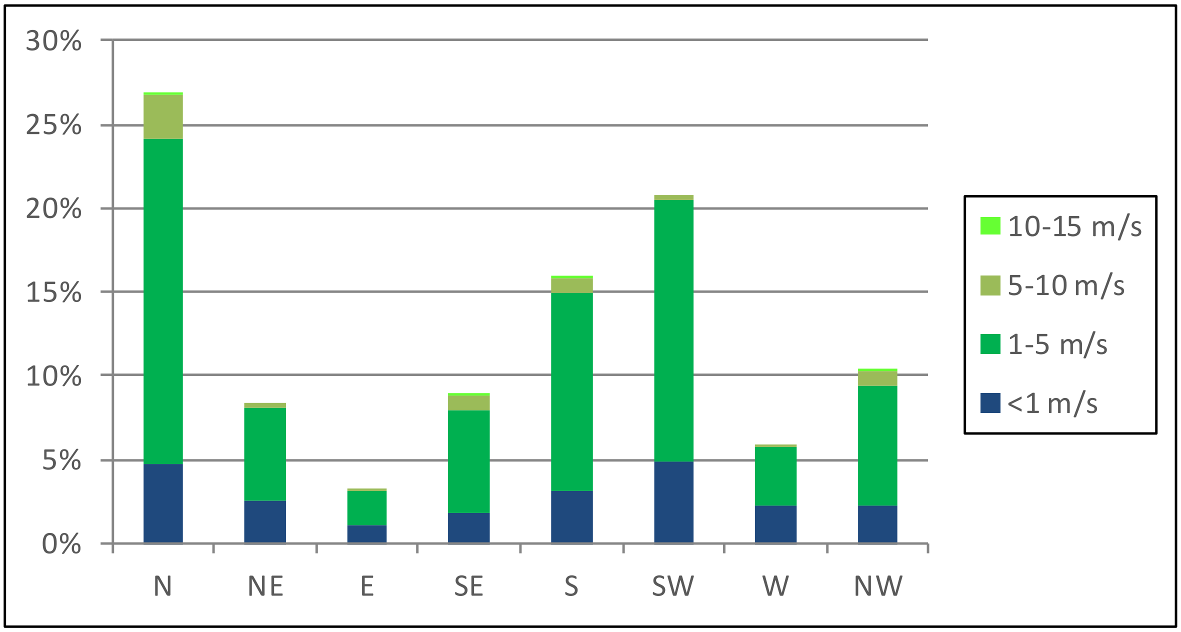

Figure B.8.2-2 Wind Data Distribution 2008-2012

B.8.2.2 Mitigations

B.8.2.2.1 R2-124

R2-124. Mitigations to reduce or eliminate the frequency and extent of air quality exceedances modeled including evidence for each mitigation's effectiveness.

As described in Section 8, the worst case scenario was modelled for the Project. This was selected by using the production schedule for the Project to determine the peak production year. For the construction phase, the worst case scenario was modelled at Year -1, because mine traffic, auxiliary power plants and pioneering are anticipated to reach their maximum at this time. For the operations phase, the worst case scenario was modelled at Year 11, because both equipment use and waste material movement reach their peak at this time.

The worst case scenario resulted in some exceedances of the Yukon Ambient Air Quality Standards largely due to the consumption of LNG at the power plant, with some impact to total suspended particulate matter (TSP) and dustfall within the mine site during mine construction. However, as it was the worst case scenario, these results are not expected to be applicable at all times but mitigations were proposed for this scenario.

Air quality mitigations for mining are derived from regulatory and non-regulatory standards published by various agencies and organizations. Monitoring during construction and operations will evaluate the effectiveness of measures that have been implemented. As described in Table 8.4-7 proposed mitigations include:

- Minimize land disturbance, grubbing and clearing activities;
- Adhere to the *Occupational Health and Safety Act*;
- Use ultra-low sulphur content fuel;
- Use construction and mining equipment that meets the latest applicable Canadian emissions standards;
- Ensure regular equipment maintenance recommended by manufacturers;

- Institute a policy for all equipment and vehicles to reduce and limit idling;
- Cover or use water sprays at dust generating area, and water unpaved portions of the road;
- Reduce drop heights for processing plants;
- Minimize wind exposure at conveyors, drop-off points and truck load/unload locations; and
- Establish blasting procedures for open pit activities to minimize dust.

The mitigations will be incorporated into the Dust Management Plan, Air Quality Monitoring Plan and Transport Management Plan to minimize potential guidelines exceedances, while also conducting long-term monitoring for air quality. These mitigations are comparable to mitigations used at other mine sites, including the Minto Mine, which has similar infrastructure to the Casino mine (i.e., open pit, unpaved roads, crusher and mill facilities). On-going monitoring of the Minto Mine indicates that these mitigation measures have been effective at keeping $PM_{2.5}$ 24-hour average values well below the Yukon Ambient Air Quality Standard (Capstone, 2013). Additionally, these mitigation measures are similar to those provided by Yukon Environment in the guidance for Dust Management Plans (Yukon Environment, 2014).

Descriptions of the proposed mitigation measures are provided below, including sources of proven effectiveness.

<u>Minimize land disturbance, grubbing and clearing activities</u>

By simply leaving material in-place, there is no opportunity for dust and particulate matter to be released from the soil. The minimization of land disturbance has been incorporated into the mine plan, by structuring the mine components as close together as possible.

<u>Adhere to the *Occupational Health and Safety Act*</u>

The Yukon Occupational Health Regulations (Yukon Workers' Compensation Health and Safety Board, 2006) under the *Occupational Health and Safety Act* (Yukon Government, 2006), requires that:

Section 8

(1) Airborne contaminants shall be controlled at their source by use of an effective local exhaust system; or where this is not practical, general ventilation systems, or a combination of the two shall be used.

(2) Local exhaust ventilation systems shall be designed so that under normal work procedures a worker is not located between the source of contamination and the exhaust intake.

(3) Where an exhaust system is installed, provision shall be made for an adequate supply of tempered make-up air. The opening of windows and doors is not adequate for this purpose.

(4) Ventilation systems shall be designed so that contaminated exhaust air is not recirculated to the work area or other work sites.

(5) Material or equipment, which will effect the efficiency of the ventilation system, shall not be piled or stored in front of ventilation openings.

(6) Wherever an operation or work process produces combustible or flammable dusts, vapours, smoke, fumes, or gases in concentrations that may exceed the lower explosive limit of that substance, such operation or work process shall be provided with an appropriate separate exhaust ventilation system.

(7) When there is a change in a work process, operation, machinery or equipment the ventilation system shall be modified as required to maintain the concentration of airborne contaminants below the levels prescribed in Tables 8 to 13 below.

And that:

Section 27. Air Contaminants

(1) A worker's exposure to airborne contaminants shall be limited to the stated permissible concentrations as specified in the tables and the preambles thereto.

(2) When there is exposure to a mixture of two or more substances listed in the air contaminant tables, the effects of such exposure shall be considered to be additive, unless it is known otherwise, and the equivalent exposure as computed below shall not exceed unity (1):

$$E = \frac{C_1}{L_1} + \frac{C_2}{L_2} + \cdots + \frac{C_n}{L_n}$$

where E = equivalent exposure to the mixture C_1 = measured time weighted average concentration of first substance etc, C_2 = measured time weighted average concentration of second substance etc, L_1 = the 8-hour time weighted average for first substance L_2 = the 8-hour time weighted average for second substance, etc.

(3) Substances listed in Table 12 shall not exceed concentrations reducing the available oxygen below 18 per cent by volume in the work place atmosphere or which will present other hazards, such as fire and explosion.

(4) A worker's exposure to substances listed in Table 7 and Table 14 for periods of time greater than 8 hours in any 24-hour period shall be limited to the modified permissible concentration (M.P.C.) calculated as:

$$M.P.C = Permissible\ Concentration\ x\ \frac{8}{h}\ x\ \frac{24-h}{16}$$

where Permissible Concentration are the values listed in Appendix A and B and h = number of hours of exposure on shift.

(5) When a worker's exposure to air contaminants exceeds permissible concentrations, the employer shall take immediate steps to reduce the worker's exposure to levels at or below the permissible concentration through engineering or administration controls.

(6) When engineering or administrative controls are not practicable the employer shall provide and the worker shall use personal protective equipment acceptable to the Chief industrial Safety Officer or the Chief Mines Safety Officer as a temporary means to control a worker's exposure to air contaminants, and the employer shall establish and maintain a health surveillance program to ensure that an exposed worker's body burden of harmful substances listed in Table 13 remains below the maximum acceptable levels.

(7) Clauses (1) and (2) do not apply

(a) when air contaminant is present in a location or at a time at which human access is impossible, or unnecessary, or not permitted, or

(b) in temporary or emergency situations or during cleaning and disposal operations, provided that workers involved have been properly trained and protective equipment worn.

Where tables 7 – 14 are defined in the *Occupational Health and Safety Act* (Yukon Government, 2006).

CMC is required to comply with the requirements in the *Occupational Health and Safety Act* and will do so to protect the health of workers.

Use ultra-low sulphur content fuel

Ultra-low sulphur diesel is that which contains less than 15 ppm sulphur. All on-road and off-road diesel fuel in Canada is required to be ultra-low sulphur diesel (Environment Canada, 2013). The sulphur limit is designed to enable compliance with diesel vehicle and engine emissions standards that have come into effect since 2010. Ultra-low sulphur is a cleaner-burning fuel, and the use of this type of fuel, in combination with newer, more efficient engines, greatly reduces NO_x and particulate matter emissions.

Use construction and mining equipment that meets the latest applicable Canadian emissions standards

Currently, construction and mining equipment must meet the *Off-Road Compression-Ignition Engine Emissions Regulations*, under the *Canadian Environmental Protection Act, 1999* (Government of Canada, 2012). The regulations are designed to reduce emissions of hydrocarbons, CO, NOx, particulate matter and other air pollutants (benzene, 1,3-butadiene, formaldehyde, acetaldehyde, acrolein and PM_{10}) from on-road and off-road vehicles and engines. The Regulations ensure that vehicles entering the Canadian market meet progressively more stringent emission standards.

Ensure regular equipment maintenance recommended by manufacturers

A poorly maintained engine can use up to 50% more fuel (D. Cope Enterprises 2004). Therefore, equipment and vehicles will be maintained as required by manufacturers, and regular inspections will be conducted with all parts showing signs of wear or damage replaced promptly.

Institute a policy for all equipment and vehicles to reduce and limit idling

Generally, each litre of gasoline used in vehicles results in 2.3 kg of CO_2 as well as CO, NO_x, criteria air contaminants and volatile organic compounds (Natural Resources Canada, 2013). Idling for more than 10 seconds uses more fuel and produces more CO_2 emissions than restarting of an engine (Natural Resources Canada, 2013), for gasoline powered engines.

Diesel powered engines (those most likely used at the mine site) produce 2.7 kg CO_2 per litre of diesel consumed (Natural Resources Canada, 2013), but consume less fuel overall due to the higher efficiency of diesel engines. Diesel engines produce more particulates and NO_x than gasoline engines, which can be eliminated when the vehicles are turned off.

Cover or use water sprays at dust generating area, and water unpaved portions of the road

Emissions from unpaved roads are generally due to the force of the wheels on the road surface, which causes pulverization of surface material, and subsequent lifting and dropping of particles from the rolling wheels and the air currents caused by the turbulent wake of the vehicle (EPA, 2006). Modeling estimates particulate emissions from re-suspended road surface material, vehicle exhaust, brake wear and tire wear. EPA (2006) describes three groupings of emission controls for unpaved roads:

1. Vehicle restrictions: including speed limits, weight limits, and limits on the number of vehicles on the road;
2. Surface improvements: including surface paving and gravel or slag to a dirt road; and
3. Surface treatment: including watering or chemical dust suppression treatments.

Surface treatment is proposed as an effective mitigation measure to prevent dust along unpaved portions of the mine and access road. Watering decreases dust by increasing the moisture content of the road surface, reducing the likelihood of the conglomerated particles becoming suspended when vehicles pass over the surface. The control efficiency depends on how fast the road dries after water is added. The frequency of watering depends on the amount of water added during each application; the weight and speed and number of vehicles traveling over the watered road and evaporation due to meteorological conditions (EPA, 2006).

Dust on unpaved roads is also greatly reduced as soon as freezing temperatures are encountered, approximately September through May.

Chemical dust suppressants are discussed further in the response to R2-128.

Reduce drop heights for process plants

Sources of process fugitive emissions may include crushing and screening operations, which exacerbate fugitive emissions by increasing the amount of fines in the material through fracturing, and the mechanical energy expended on the fines generates high velocity air streams within the process equipment (EPA, 1996). Generally, these processes are enclosed, and therefore the fugitive emissions escaping to the open air is reduced, but is still relevant due to process leaks (EPA, 1996). The calculation for fugitive emissions is directly dependent on the drop height from the process equipment (e.g., conveyor).

As such, source reduction measures recommended by the EPA (1998) includes drop height reduction through the use of hinged-boom conveyors, rock ladders, lower wells, etc., which may result in control efficiencies of 80%, 75% and 50%, respectively. Further, using choke-feed or telescopic chutes and washing down or scraping conveyor belts regularly is also cited as effective mitigation measures to minimize particulate matter generating materials (EPA, 1998).

Minimize wind exposure at conveyors, drop-off points and truck load/unload locations

Fugitive dust is emitted from mine sites at locations where the transfer, storage and handling of materials results in exposure to wind or machinery. Fugitive dust emissions result whenever material is added to or removed from a storage pile and is based on wind speed and material moisture content, the more moist and still the air is, the fewer emissions (EPA, 1996). Further, wind erosion of open aggregate piles and exposed areas within an industrial facility (e.g., conveyors) may also result in fugitive dust emissions (EPA, 1996). Minimizing the wind exposure at these areas results in a direct decrease in fugitive dust emissions, including PM_{10} emissions.

Other mitigations typically used on conveyor systems include loading the material onto the centre of the belt, adequately spaced impact idlers at transfer points, conveyor skirtboards to provide a dust seal between the skirtboards and the moving belt and dust curtains (U.S. Bureau of Mines, 1987).

Establish blasting procedures for open pit activities to minimize dust

Drills, blasting and crushers produce the most dust in hard rock open pit mines (Kissell, 2003). Drill dust can be controlled by water injected through the drill steel, which results in a 95% or better reduction in respirable dust (Kissell, 2003). During blasting, water is used to spray the blast area beforehand, and generally, the faces are shot during an off-shift, so no workers are in the mine at the time of the blasts (Kissell, 2003). In hard rock mines, the dust is usually cleared within 2 hours (Chekan and Colinet, 2002). Further, new enclosed cabs on drills and bulldozers can effectively control the operator's dust exposure, with good cab sealing and pressurization systems, and filtration/air conditions systems (Kissell, 2003).

B.8.2.2.2 R2-125

R2-125. Unclassed air quality model outputs in a standard GIS format.

Air quality model output files in GIS are attached to this submission in digital format as Appendix B.8.A. These files include:

- Construction:
  - CO: 1 hour & 8 hour
  - Daily dustfall
  - NO_2: 1 hour, 24 hour & annual
  - $PM_{2.5}$: 24 hour & annual
  - PM_{10}: 24 hour
  - SO_2: 1 hour, 24 hour & annual
  - TSP: 24 hour & annual
- Operations:
  - CO: 1 hour & 8 hour
  - Daily dustfall
  - NO_2: 1 hour, 24 hour & annual
  - $PM_{2.5}$: 24 hour & annual
  - PM_{10}: 24 hour
  - SO_2: 1 hour, 24 hour & annual
  - TSP: 24 hour & annual

B.8.3 DUST AND DUSTFALL

B.8.3.1.1 R2-126

R2-126. Predicted change in dust composition during construction and operations.

As described in Appendix A.8A, large unit construction activities are expected to have a beginning and an end and vary over the construction phase as activities change on a daily basis. General construction emission factors were used by assuming that each unit requiring erection would take around 90 days of heavy construction activity. Construction activities includes construction of the power plant, concentrator and crusher area for total emissions of ~63 tonnes/year, 30 tonnes/year and 4.5 tonnes/year of TPM, PM_{10} and $PM_{2.5}$, respectively. However, fugitive dust emissions during construction is dominated by dust from haul roads and, as summarized in Table A.8A.1-9, ~562 tonnes/year, 150 tonnes/year and 52 tonnes/year of TPM, PM_{10} and $PM_{2.5}$, respectively. The total emissions during peak construction year were provided in Table A.8A.1-10 in Appendix A.8A, and are provided in Table B.8.3-1 below.

Modeled total suspended particulate (TSP) and dustfall levels show exceedances within the mine site but not at the Freegold Road (Figures 8.4-9, 8.4-10 and 8.4-14). PM_{10} and $PM_{2.5}$ levels show exceedances throughout the mine site and extending out into portions of the Freegold Road immediately east of the mine site (Figures 8.4-11 through 8.4-13).

Table B.8.3-1 Total Particulate Matter Emissions during Peak Construction Year

Mine Facility	Total TPM (tonnes/year)	Total PM_{10} (tonnes/year)	Total $PM_{2.5}$ (tonnes/year)
Roads			
Haul Road 1	184.4	48.8	4.9
Haul Road 2	148.3	39.3	3.9
Haul Road 3	192.0	50.8	5.1

Mine Facility	Total TPM (tonnes/year)	Total PM_{10} (tonnes/year)	Total $PM_{2.5}$ (tonnes/year)
Haul Road 4	58.2	15.4	1.5
Haul Road 5	0.4	0.1	0.03
Access Road	376.9	94.0	41.2
Airport Road	185.1	54.6	11.2
Crusher Unit			
Crusher	90.2	9.0	9.0
Truck Unloading	0.008	0.004	0.001
Sulphite Ore Plant			
Conveyor Drop Off	0.026	0.008	0.002
Sag Mill	-	-	-
Pebble Crushing	-	-	-
Cyclone	-	-	-
Ball Mill (Before Mitigation)	268.2	71.5	71.5
General Construction Activities *			
Power Plant	36.3	17.2	2.6
Concentrator	24.2	11.5	1.7
Second Crusher	2.0	1.0	0.1
Earth Moving/Surfacing			
Gold Ore Stockpiles	97.0	72.8	10.2
Supergene Oxide Ore Stockpiles	164.4	123.3	17.3
Waste Storage Dump	181.7	136.2	19.1
Loading/Unloading			
Gold Ore Stockpiles	2.3	1.1	0.2
Supergene Oxide Ore Stockpiles	1.1	0.5	0.1
Waste Storage Dump	0.56	0.26	0.04
Wind Erosion			
Gold Ore Storage Area	1.6	0.8	0.3
Low Grade Supergene Oxide Pile	0.5	0.2	0.1
Supergene Oxide Ore Stockpile	1.9	0.9	0.4
Marginal Grade Ore Pile	1.9	0.9	0.4
Low Grade Supergene Sulphite	0.5	0.2	0.1
Waste Storage Area	0.3	0.1	0.0
Topsoil Piles	10.1	5.0	2.0
Topsoil Overburden Piles	12.5	6.5	2.6
ANNUAL TOTAL (tonnes)	**2043**	**762**	**206**

*Assumed that construction at Power Plant, Concentrator Building and Second Crusher could take 90 days

Conversely, during the Operation Phase, the main contributors to emissions are the Power Plant, Open Pit activities, and Unpaved Roads, with unpaved roads continuing to be the largest source of particulate matter for the Project due to haul road distances between key Project infrastructure. As summarized in Table 8.4-5, air quality interactions that occur during operations and not construction include concentrate and ore and waste transport and loading, open pit particulate matter emissions, emissions from crushers and processing facilities, and wind erosion effects on ore stockpiles, waste stockpiles and the tailings beach. The total emissions during operations were summarized in Table A.8A.2-11 in Appendix A.8A, and are provided in Table B.8.3-2 below.

Table B.8.3-2 Total Particulate Matter Emission During Operations

Mine Facility	Total TPM (tonnes/year)	Total PM_{10} (tonnes/year)	Total $PM_{2.5}$ (tonnes/year)
Roads			
Haul Road 1	1539	395	40
Haul Road 2	33	8	1
Haul Road 3	26	7	1
Haul Road 4	3	1	0.1
Haul Road 5	117	30	3
Haul Road 6	92	24	2
Haul Road 7	478	123	12
Haul Road 8	3	1	0.1
Access Road	1508	1442	144
Airport Road	85	82	8
Crusher unit to sulphide ore facility			
Crusher	893.9	89.4	89.4
Truck Unloading	0.076	0.036	0.036
Crusher unit to oxide ore facility			
Crusher	155.1	15.5	15.5
Truck Unloading	0.062	0.029	0.004
Sulphide ore plant			
Conveyor Drop Off	67.0	24.6	24.6
SAG Mill	-	-	-
Pebble Crushing	-	-	-
Cyclone	-	-	-
Ball Mill	268.2	71.5	71.5
Oxide ore plant			
Conveyor Drop-Off	11.8	4.3	4.3
Screening	59.0	14.2	14.2
Secondary Crushing	235.9	111.6	16.9
Earth moving/surfacing			

Mine Facility	Total TPM (tonnes/year)	Total PM_{10} (tonnes/year)	Total $PM_{2.5}$ (tonnes/year)
Low Grade Supergene Stockpiles	164.4	123.3	17.3
Gold Ore Stockpiles	97.0	72.8	10.2
Supergene Oxide Ore Stockpiles	164.4	123.3	17.3
Low Grade Hypogene Ore Stockpiles	164.4	123.3	17.3
Low Grade Supergene Oxide Stockpiles	82.2	61.6	8.6
Waste Storage Dump	90.8	68.1	9.5
Loading/unloading			
Low Grade Supergene Stockpiles	0.028	0.013	0.002
Gold Ore Stockpiles	0.831	0.393	0.060
Supergene Oxide Ore Stockpiles	0.006	0.003	0.0004
Low Grade Hypogene Ore Stockpiles	0.028	0.013	0.002
Low Grade Supergene Oxide Stockpiles	0.0018	0.0008	0.0001
Waste Storage Dump	0.891	0.013	0.004
Wind erosion			
Gold Ore Storage Area	1.87	0.94	0.37
Low Grade Supergene Pile	1.87	0.94	0.37
Supergene Oxide Ore Stockpile	1.87	0.94	0.37
Low Grade Hypogene Ore pile	1.87	0.94	0.37
Low Grade Supergene Oxide	0.47	0.23	0.09
Waste Storage	0.09	0.04	0.01
Tailings Beach	13.42	6.72	2.68
ANNUAL TOTAL (tonnes)	**6362**	**3027**	**532**

During operations, TSP and dustfall levels show minor exceedances within the mine site but not at the Freegold Road (Figures 8.4-23, 8.4-24 and 8.4-28). PM_{10} and $PM_{2.5}$ levels show exceedances throughout the mine site and extending out into portions of the Freegold Road immediately east of the mine site (Figures 8.4-25 through 8.4-27).

The assessment described above is a standard approach to model emission sources and air quality using guidelines issued by several regulatory agencies such as Environment Canada's Pits and Quarries Guidance (NPRI, 2009), United States Environmental Protection Agency AP-42 (US EPA 1995), and Australian Mining Emission Estimation Technique Manuals (NPI 2008, NPI 2012). The model predicts emissions of primary air pollutants including NO_x, SO_2, fine particles (TPM, PM_{10} and $PM_{2.5}$), CO and dustfall. Secondary pollutants, including toxic metals (e.g., cadmium, chromium, nickel, and manganese) are not predicted by the standard models. Additionally, the formation of secondary pollutants due to the emissions of primary pollutants is predicted to be negligible.

However, to ensure protection of human health, in the absence of the prediction of secondary pollutants, the Yukon Ambient Air Quality Standards or other relevant ambient air quality objectives (Table 8.4-1) can be considered *de facto* risk-based thresholds derived from the best available epidemiological and toxicological knowledge, and subjected to prior regulatory and scientific peer review. As described in the response to R444, the only identified exposure scenario for workers at the mine site is through the pulmonary (inhalation) exposure route. As described above in the response to R2-124, CMC will comply with requirements of the Yukon Occupational Health Regulations (Yukon Workers' Compensation Health and Safety Board, 2006) under the *Occupational Health and Safety Act* (Yukon Government, 2006) to maintain worker health.

Finally, CMC will be required to obtain an Air Emissions Permit for:

- Burning more than 5 kg per day of garbage; and
- Electricity generating facility with a capacity >1MW (Yukon Environment, N.D.).

As part of that permit, CMC will submit a Dust Management Plan, which will "*demonstrate how appropriate management techniques will reduce the potential for any dust-related adverse effect to public health or the environment, and describe the measures that will be undertaken to control dust generated by the operation*" and will include "*dust produced by bulk materials handling, storage activities, earth-moving, construction, demolition or vehicular movements*" (Yukon Environment, 2014). The Dust Management Plan will be submitted as part of the application for a permit under the Yukon's Air Emissions Regulations prior to the commencement of either of the above listed activities.

B.8.3.1.2 R2-127

R2-127. Discussion on additional dust sources such as project induced wind-based erosion, blasting, and traffic in relation to dust quantity, including details on the inclusion of these sources in air quality modeling.

For a full list of sources used as inputs in the air quality mode, the Executive Committee is referred to Appendix A.8A Emissions Inventory for Construction and Operations. However, for ease of consideration, the prediction of dust due to wind-based erosion, blasting and traffic, is summarized below, with the full numerical values of all sources in construction and operation summarized in Table B.8.3-1 and Table B.8.3-2, above.

<u>Wind-based Erosion</u>

Site historical meteorological data indicate that the Project does not experience wind gusts very often. The wind speeds exceeded 5.4 m/s hourly average only 4.4% of the time from 2008 to 2012 (Table B.8.2-3). Considering the gust speed and approximate silt contents, particulate matter emissions were estimated for each ore, waste, and topsoil stockpiles. Usually topsoil stockpiles are covered by grass however during the construction phase, it was assumed to be too early for vegetation growth and they are included in wind erosion estimations. During operations, the erosion related particulate emission were estimated and used in the model for exposed stockpiles and tailings beach. Wind erosion emission estimates are summarized in Table B.8.3-3.

Table B.8.3-3 Wind Erosion Emissions

Mine Facility	Construction Value (tonnes/year)			Operations Emission Factor (tonnes/year)		
	TPM	PM_{10}	$PM_{2.5}$	TPM	PM_{10}	$PM_{2.5}$
Gold Ore Stockpile	1.64	0.82	0.33	1.87	0.94	0.37
Low Grade Supergene Oxide Pile	0.47	0.23	0.09	1.87	0.94	0.37
Supergene Oxide Ore Stockpile	1.87	0.94	0.37	1.87	0.94	0.37
Low Grade Hypogene Ore Stockpile (4 ha)	-	-	-	1.87	0.94	0.37
Marginal Grade Ore pile	1.87	0.94	0.37	-	-	-
Low Grade Supergene Sulphite	0.47	0.23	0.09	0.47	0.23	0.09
Waste Storage Area	0.29	0.14	0.03	0.09	0.04	0.01
Topsoil Piles	10.06	5.04	2.01	-	-	-
Topsoil Overburden Piles	13	6.5	2.6	-	-	-
Tailings Beach (18 ha)	-	-	-	13.4	6.7	2.7

Blasting

Detailed blasting data were not available, therefore the ANFO use was estimated by using 0.25 times the powder factor and material extracted from the open pit in a year. It was assumed that blasting emissions would disperse in one hour which is the shortest modelling time interval for this study. The blasting was also assumed to occur once a day. Table B.8.3-4 summarizes the blasting emission estimations.

Table B.8.3-4 Blasting Emissions

Species	Emission Factor [a] (kg/Mg ANFO)	Construction			Operations		
		Daily ANFO [b] (tonnes)	Daily Air Emissions (kg)	Emission Rate [d] ($g/s/m^2$)	Daily ANFO [c] (tonnes)	Daily Air Emissions (kg)	Emission Rate [d] ($g/s/m^2$)
CO	34	28.34	963.55	$1.12x10^{-03}$	67.63	2299.33	1.18x10-03
NO_x	8	28.34	226.72	$2.62x10^{-04}$	67.63	541.02	2.78x10-04
SO_2	1	28.34	28.34	$3.28x10^{-05}$	67.63	67.63	3.48x10-05

a. EPA 2006
b. Assuming a powder factor of 0.250 Kg ANFO/tonnes with 41,376,000 tonnes extraction during year -1
c. Assuming a powder factor of 0.225 Kg ANFO/tonnes with 98,736,000 tonnes extraction during year 11
d. Assuming that blasting emissions will be released from 10,000 m^2 surface within one hour

Traffic

Fugitive dust from haul roads is the largest and most frequent contributor to particulate matter emissions. It was assumed that a dust control program (i.e. applying water to control dust emissions) would be applied and would control fugitive dust emissions from haul roads by approximately 75%, and natural mitigation (precipitation and snow cover) would also aid to suppress fugitive dust. The Whitehorse and Burwash weather stations were considered for natural mitigation data and Whitehorse was used in calculations (67.9%) as a conservative approach. Regular activity consists of ore/waste hauling, explosive transport, airport transportation and access road materials supply and concentrate transport. AP-42 Section Unpaved Roads (EPA, 2006) was used as the main reference to calculate emissions by using the following formula:

$$E = k\left(\frac{s}{12}\right)^a\left(\frac{W}{3}\right)^b$$

where:

- E = size specific emission factor (lb/VMT)
- s = surface material silt content (%)
- W = mean vehicle weight (tonnes)
- k (lb/VMT) = 0.15 for $PM_{2.5}$, 1.5 for PM_{10} and 4.9 for TPM
- a = 0.9 for $PM_{2.5}$ and PM_{10} and 0.7 for TPM
- b = 0.45 for $PM_{2.5}$, PM_{10}, and TPM

The truck trips were estimated by using the annual production schedule and the capacity of haul trucks. The summary of the unpaved road emissions is provided in Table B.8.3-5.

Table B.8.3-5 Unpaved Road Emissions

	Construction					Operations				
Road Type	**Avg. Weight**	**Travelled Distance**	**TPM**	**PM_{10}**	**$PM_{2.5}$**	**Avg. Weight**	**Travelled Distance**	**TPM**	**PM_{10}**	**$PM_{2.5}$**
	(tonnes)	**(km)**	**(tonnes/year)**			**(tonnes)**	**(km)**			
Haul Road 1 To Waste Storage Area	443	766	184.4	48.8	4.9	443	7097.3	1539	395	40
Haul Road 2 Low Grade Hypogene Stockpile	-	-	-	-	-	443	150.8	33	8	1
Haul Road 3 Low Grade Supergene Sulphide Stockpile	-	-	-	-	-	443	118.7	26	7	1
Haul Road 4 Low Grade Supergene Oxide Stockpile	-	-	-	-	-	443	12.9	3	1	0.1
Haul Road 5 Supergene Oxide Stockpile	443	617	148.3	39.3	3.9	127	537.5	117	30	3
Haul Road 6 Gold Ore Stockpile	443	798	192	50.8	5.1	127	426.5	92	24	2
Haul Road 7 Direct Mill Feed	443	242	58.2	15.4	1.5	443	2202.3	478	123	12
Haul Road 8 Explosive Storage	30	5	0.4	0.1	0.03	30	13.9	3	1	0.1
Access Road	30	1,617	376.9	94	41.2	30	6469.5	1508	1442	144
Airport Road	30	440	185.1	54.6	11.2	30	366.6	85	82	8

B.8.3.1.3 R2-128

R2-128. Water requirements for dust management and dust prevention strategies and details on any water additives.

CMC has proposed to mitigate exceedances of Yukon Ambient Air Quality Guidelines through water sprays at dust generating areas, watering unpaved portions of the road to minimize fugitive dust and watering of access corridors. The water used for dust management will be sourced from the freshwater pipeline (i.e., Yukon River).

If a dust suppressant other than water is being considered for use, for any of the following considerations, advance written approval will be obtained from Yukon Environment (Yukon Environment, 2014):

- Safety: Accident potential is increased due to loss of visibility;
- Health: Dust particles may become a health hazard;
- Vegetation: Dust may induce changes in vegetation due to increased heat absorption and decreased transpiration;
- Aquatic resources: Dustfall into aquatic systems may adversely affect aquatic plants and fish that are not adapted to high levels of sedimentation;
- Road maintenance costs: Treated roads can lower road maintenance costs by reducing gravel loss and blading time; and
- Aesthetics: dust produces an immediate visual impact (Government of the Northwest Territories, 2013).

Generally, engineering is used to construct well designed roads to withstand expected vehicle loads, that is well drained, and the size of materials in the surface layer is selected to achieve maximum durability (FCM and NRC, 2005). Where all reasonable engineered methods are not able to reduce dust emissions to minimize the above considerations, chemical dust suppressants (those which bind the particles in a road surface together to prevent escape to the atmosphere), may be considered.

Common dust suppressant additives (i.e., above and beyond just water) include:

- Lignin derivatives;
- Synthetic polymer emulsions;
- Bitumens, tars, and resins;
- Calcium chloride; and
- Magnesium chloride (FCM and NRC, 2005).

Each suppressant has functional, application, performance and environmental factors which must be considered when evaluating which suppressant to use. Yukon Highways and Public Works uses Bituminous Surface Treatments (BST) as an alternative to calcium chloride (Yukon Government, 2015). As stated above, any suppressant used by CMC will only be used following advanced written approval obtained from Yukon Environment.

Calcium chloride has been used in the Yukon effectively (Yukon Government, 2015). Using the manufacturer's specifications for water requirements, over the entire 120 km road, a water consumption volume is estimated at 1,000 m^3 of water per application. Depending on the number of applications, based on air temperature and precipitation, the total water consumption for 2 – 3 applications of calcium chloride per year would be ~3,000 m^3. Conversely, watering the road alone, without additives, would consume approximately 1,200 m^3 of water per application, and would need to be applied much more frequently, again depending on the air temperature and precipitation, therefore can be expected to be greater than 3,000 m^3.